even apart from its greater economy in time, the direct-reading machine has a still further advantage in that it is possible to secure more accurate results than with the use of the curve-tracing type. The dials on the direct-reading tide predictor are graduated to single minutes and to single tenths of a foot; it is, therefore, not difficult to estimate to within half a minute or five hundredths of a foot. To estimate as closely from a curve drawn to a moderate time-and-height scale is well-nigh impossible.

Since the tide predictor sums a number of continuous functions, it cannot be made to give the exact results of an adding or a multiplying machine. And because of the large number of moving parts that enter into the construction of a tide predictor, we cannot hope to secure the accuracy that may be obtained with a planimeter. In fact, the errors of the tide predictor may be ascribed almost wholly to the varying tensions on the numerous moving parts, but it appears that these errors should not be large enough to be serious.

In 1910 the U.S. Coast and Geodetic Survey put into operation a direct-reading tide predictor which had been constructed in its instrument division. Prior to the use of this machine for the prediction of tides for the annual tide tables it was carefully tested, one of the tests consisting in the comparison of the hourly heights of the tide as given by the machine and as computed analytically "by hand." The machine was set with 30 components for Hong Kong, China, January 1, 1912, and run through to December 31. For that day hourly heights of the tide were read off for the entire twenty-four hours.

At the beginning of this year, after it had been in use about twelve years, the machine was again set for Hong Kong, January 1, 1912, and run through to December 31, and the hourly heights read off. December 31 was chosen so that all errors due to the incommensurability of the speeds of the various components might accumulate. The table below shows the differences between the computed and the predicted heights :—

Hourly Heights of Tide, Hong Kong, China, December 31, 1912.

	Predicted in			Differences	
Hour	1910. Feet.	1922. Feet.	Computed. Feet.	1910. Feet.	1922. Feet.
0	4·28	4·30	4·32	−0·04	−0·02
1	4·65	4·67	4·68	−0·03	−0·01
2	4·78	4·78	4·80	−0·02	−0·02
3	4·60	4·61	4·59	+0·01	+0·02
4	4·07	4·08	4·05	+0·02	+0·03
5	3·27	3·27	3·22	+0·05	+0·05
6	2·32	2·32	2·28	+0·04	+0·04
7	1·42	1·42	1·37	+0·05	+0·05
8	0·70	0·70	0·66	+0·04	+0·04
9	0·31	0·31	0·27	+0·04	+0·04
10	0·34	0·33	0·33	+0·01	0·00
11	0·76	0·78	0·81	−0·05	−0·03
12	1·51	1·52	1·56	−0·05	−0·04
13	2·31	2·32	2·37	−0·06	−0·05
14	3·00	3·01	3·06	−0·06	−0·05
15	3·48	3·48	3·53	−0·05	−0·05
16	3·70	3·68	3·73	−0·03	−0·05
17	3·64	3·63	3·66	−0·02	−0·03
18	3·38	3·38	3·40	−0·02	−0·02
19	3·04	3·06	3·07	−0·03	−0·01
20	2·73	2·74	2·75	−0·02	−0·01
21	2·50	2·52	2·51	−0·01	+0·01
22	2·46	2·47	2·47	−0·01	0·00
23	2·64	2·66	2·67	−0·03	−0·01

It is to be noted that the height-scale on the tide predictor is graduated to tenths, so that the hundredths were estimated. The differences between the heights as predicted and as computed are relatively small, in no case exceeding 0·06 ft. It is also interesting to note the close agreement between the predictions made in 1910 and those in 1922, these predictions being made not only twelve years apart, but also by different persons. It is only proper to add that these predictions were undoubtedly carried out with more than ordinary care, owing to the psychological effect of the knowledge that a test was involved. Furthermore, it must be stated that with a single-component tide the accuracy attained was not so gratifying as in the example given above, the reason being that with a number of components there are compensating tensions of the moving parts, while with a single component there are no such compensations. It is to be borne in mind, however, that in the prediction of tides there is always a considerable number of components involved.

It would be unfortunate if the impression that tide predictors are subject to serious errors gained currency, for, apart from the use of such machines for the prediction of tides for the tide-tables, there are numerous tidal problems involving time-consuming computations which may be very easily made with the tide predictor. In the elimination of the effects of short-period tides on daily mean sea-level, in the computation of the changes in sea-level due to tides of long period, in the elimination from the observed tide of the tide due to a number of constituents, and in similar problems, the tide predictor should very materially lessen the laborious computations involved.

H. A. MARMER.

U.S. Coast and Geodetic Survey, Washington,
D.C., January 5.

THE errors found in the British tide-predicting machines referred to in the article were more serious than those described by Mr. Marmer. The machines were of the curve-tracing type, and therefore inevitably less accurate (with the time and height scales ordinarily used) than direct-reading machines; they had zero errors, and also diminished the apparent range of the tide. The direct-reading machine used by Mr. Marmer is both more accurate and quicker in use; for many purposes, though perhaps not for all, such a machine is a valuable substitute for numerical computation.

THE WRITER OF THE ARTICLE.

The Oxidation of Ammonia.

THE following details of the early history of the oxidation of ammonia, a process which became of great importance during the war, do not appear generally to be known, and may be of interest. The first clear statement of the oxidation of ammonia which I have seen is contained in a paper by the Rev. Isaac Milner, B.D., F.R.S., president of Queens' College, Cambridge, published in the Philosophical Transactions for 1789 (vol. 79, pt. 2, pp. 300–13), and republished in Crell's *Annalen* (1795, pt. 1, pp. 550–62). The title of the English paper is "On the Production of Nitrous Acid and Nitrous Air," and the German paper is a translation, in which "nitrous acid" is rendered "Saltpetersäure" and "nitrous air" (*i.e.* nitric oxide, NO) "Saltpeterluft."

Milner remarks that, although the relation between nitrous acid and the volatile alkali was known, there was no known case in which the latter was used in the production of nitrous acid or nitrous gas. In

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March, 1788, he tried the experiment of fitting a retort containing caustic volatile alkali to a gun-barrel filled with crushed pyrolusite (maganese dioxide), and heating the latter to redness, whilst the retort was also heated. Signs of nitrous acid and nitrous air soon made themselves manifest, and by continuing long enough nitrous gas was obtained. The experiment was repeated many times; its success depended on the nature of the pyrolusite, the temperature of the furnace, and the patience of the experimenter. Full details are given as to the best way of carrying out the experiment. It frequently happens that the ammonia passes over unchanged. Red lead was found, unexpectedly, not to be active, but green vitriol burnt white gave better results.

The changes are correctly explained by Milner as due to oxidation. With burnt alum he obtained the curious result of the evolution of a large amount of inflammable gas mixed with hepatic air (sulphuretted hydrogen) and sulphur, whilst sulphur remained in the gun-barrel. It is, therefore, not sufficient merely to bring the volatile alkali in contact with a substance containing dephlogisticated air, but another substance is also necessary which has a strong attraction for the combustible substance.

It is also noteworthy that Black in his "Lectures on Chemistry" (edited by John Robison, Edinburgh, 1803) states that "our newspapers inform us that the French chemists procured saltpetre for the Army by blowing alkaline gas, and even putrid steams, through red-hot substances which readily yield oxygen" (vol. 2, p. 245); and there is a statement that "Mr. Milner of Oxford (*sic*) published a paper in the 79th volume of the Philosophical Transactions . . . but he did not attempt to ascertain how much of the nitrous acid might be produced from a limited and known quantity of the volatile alkali" (vol. 2, p. 455). Black (*ibid.*) gives a clear explanation of the process; the ammonia "is a compound of hydrogen and azote, we need only suppose that part of it is totally decomposed and destroyed by the action of the oxygen contained in the manganese. Part of it, uniting with the hydrogen, forms water or watery vapour; and part, uniting with the azote, forms vapours of nitrous acid." I have not traced the reference to the "newspapers," but a footnote on the same page (455) reads: "*January*, 1796. There is a rumour that the French have manufactured saltpetre, during a part of the war, by obtaining nitrous acid from the vapours of volatile alkali, forced to pass through red hot manganese. Author."

Many strange names have of late been given to the process of ammonia oxidation; we have heard of the "Ostwald-Mittasch process" and others. The first use of platinum as a catalyst appears to be due to Kuhlmann, of Lille, in 1839. J. R. PARTINGTON.

45 Kensington Gardens Square, W.2.

A Specimen of Wrought-iron Currency from the Kisi Country, Sierra Leone Protectorate, West Africa.

A SPECIMEN of iron currency from the Kisi country was obtained by one of us (E. R. M.) while on service in West Africa in 1915 through the agency of his servant, Ali Badara, the son of a chief in the adjoining Momo-Fullah country; and a description of it may be of interest to readers of NATURE.

As this form of currency ceased to be used after the establishment of the British Protectorate in 1787, the age of the specimen may be estimated at not less than 130 years, and probably more.

The "coin" (Fig. 1) is of rough workmanship, and consists of a strip of roughly forged rectangular section, one half being twisted and the ends hammered out into thin blade-like projections, the broad end serving to prevent the "coin" slipping through the belt in which it is carried.

Analysis shows the metal to be wrought-iron of good quality, probably made by the direct process of reducing an oxide ore by carbon in presence of a basic slag containing much iron oxide to prevent carburisation of the iron, most of the slag then being expressed by hammering the pasty mixture of iron and slag. The percentage composition is as follows: Carbon, 0·095; silicon, 0·103; manganese, nil; sulphur, 0·024; and phosphorus, 0·046. For the analysis drillings were taken from the wider part of the specimen and fragments from the narrow end. These were washed in benzene to remove the coating of black grease from the surface of the metal.

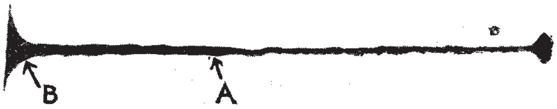

FIG. 1.—Photomicrograph × 1/5.

The metal is extremely soft and easily bent, the Brinell hardness at the point A being 121 (using a ball 1 mm. diameter and a load of 10 kilograms). A small fragment was cut from the point B, embedded in solder, polished, etched with 2 per cent. nitric acid in alcohol, and photomicrographed. The photomicrograph (Fig. 2) shows the typical crystalline structure of a pure iron, together with elongated inclusions of slag.

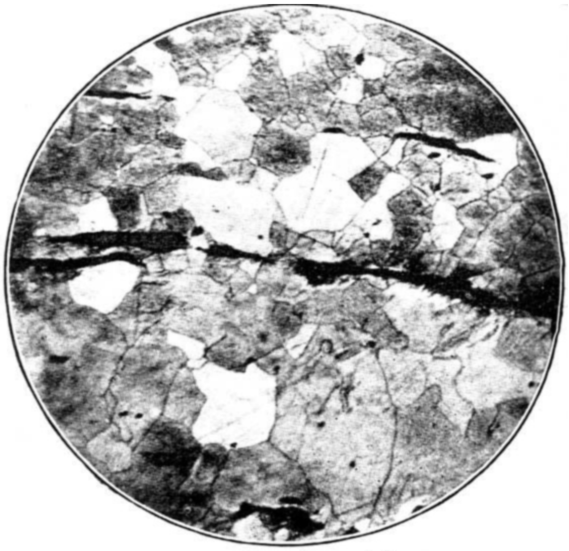

FIG. 2.—Photomicrograph × 275.

R. C. GALE.
E. R. MACPHERSON.

Chemistry and Metallurgy Branch,
Artillery College, Woolwich.

Molecular Structure of Amorphous Solids.

A QUESTION of fundamental importance in the theory of the solid state is the nature of the arrangement of the ultimate particles in amorphous or vitreous bodies, of which glass is the most familiar example. Is it to be supposed that the molecules are packed

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